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Editorial

Orthopedists should never forget the utility of osteotomy as an option for regenerative medicine: the importance of joint preservation surgery and its dissemination

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Introduction

Among the various types of osteotomy, most have been designed and applied to hip joints. Because the hip joint supports the largest body load and has special characteristics from the viewpoint of structural function, it is prone to various diseases and degenerative conditions. Therefore, it has been said that a surgeon who can control the hip joint is able to master the field of orthopedics.

Based on past experience, hip surgeons have seen that articular cartilage regenerates after osteotomy employed to treat osteoarthritis in the hip. The regeneration manifests on X-ray films as widening of the joint space after surgery. Such regeneration of articular cartilage has been confirmed by magnetic resonance imaging (MRI) and arthroscopy and by biopsy, although histologically this cartilage is not exactly the same as the original articular cartilage.

In cases of osteonecrosis of the femoral head, if the progression of collapse is prevented by a transtrochanteric rotational osteotomy as well as a transtrochanteric curved varus osteotomy, necrotic lesions are replaced by appositional new bone formation, which subsequently results in normal bone and bone marrow tissue. This has been confirmed by radiography, MRI, and histology.

In other words, when the progression of collapse and subsequent joint deformity are prevented by osteotomy, which transposes the normal articular surface with normal bone trabeculae to the weight-bearing portion, the necrotic bone trabeculae are replaced by viable bone. If joint realignment can be achieved by osteotomy, thus spreading and averaging the load, articular cartilage is regenerated. This phenomenon can be observed not only in hip joints but also in the knee and other joints.

Although regenerative medicine has recently seen a sudden resurgence of popularity, there seems to be a view that its use is limited to tissue regeneration by transplantation of tissue cultured in vitro using embryonic stem cells or somatic stem cells. However, I believe that regeneration of tissue by stimulating primitive mesenchymal stem cells already present in the living body and by providing an environment suitable for the regeneration of the required cells is a natural form of regenerative medicine. This practice has long been used in the domain of orthopedics. Thus, it is obvious that joint regeneration by osteotomy is one representative type of regenerative medicine.

Research on bone fracture healing mechanisms and heterotopic bone formation has been conducted since the eighteenth century, when it was first recognized that bone tissue has particularly strong regenerative potential. The concept of bone induction was formulated more recently. After M.R. Urist, one of the advocates of this concept, first reported the existence of bone morphogenetic protein (BMP), research on BMP advanced rapidly during the second half of the twentieth century.

In 1964, Till and McCulloch carried out bone marrow transplants in lethally irradiated mice and observed the formation of many cell colonies in the spleens of these mice. They called them "colony-forming units" (CFU). A CFU is a colony formed by a single hematopoietic stem cell. Their dissertation is thought to have been the first to establish the stem cell concept. Surprisingly, however, in 1962 C.A.L. Bassett (Orthopedic Research Laboratories, Department of Orthopedic Surgery, Colombia University College of Physicians and Surgeons) had already presented an instructional course lecture at the American Academy of Orthopaedic Surgeons (AAOS) in which he stated that induction of cartilage, bone, and tendinous fiber tissue can be observed during

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the culture of immature mesenchymal stem cells by changing features of the culture environment, such as compaction and tension as well as the oxygen concentration. Thus, he had already clarified the fact that cartilage, bone, and tendon tissue differentiate from mesenchymal stem cells when the culture environment is changed.

Osteotomy is completely different from fracture

We should recognize that osteotomy is a quite different surgical option from osteosynthesis. It is erroneous to assume that when strong internal fixation is done after an osteotomy, the affected part is able to withstand full weight-bearing. Because the bone fragments have been moved and displaced by the osteotomy, the orientation of the bone trabeculae in relation to the load has been radically changed, and the fragments cannot tolerate full weight-bearing until restructuring of the new bone is complete.

For instance, during a transtrochanteric rotational osteotomy the weight-bearing articular surface is rotated 90°. The non-weight-bearing part is moved to the weight-bearing part, and the bone trabeculae supporting the articular cartilage, which has now moved to the weight-bearing portion, is turned in a completely different direction. Therefore, it is obvious that before full weight-bearing can be permitted, it is necessary to wait for the restructuring of new supporting bone trabeculae, which can be achieved only by gradual application of partial loads. Otherwise, osteoarthritis may occur even if the condition is not particularly bad; and in the worst-case scenario, a fracture occurs in the femoral neck or the loading causes collapse of the joint surface or serious destruction of the articular cartilage, with catastrophic results. Also, with transpositional osteotomy of the acetabulum (TOA), blood flow in the transposed bone fragment may decrease; and if full weight-bearing is undertaken just after the operation without waiting for recovery of sufficient blood circulation, collapse and destruction of the transposed bone fragments certainly occurs. The most important issues for the orthopedist after an osteotomy are that (1) blood flow in the transposed bone fragments is decreased and (2) the orientation of the bone trabeculae differs completely from the original orientation. Therefore, even if strong internal fixation material is used, it is necessary to apply partial weight-bearing followed by a gradual, stepwise increase of the load, although joint movement exercise without weight-bearing needs to be considered.

Each Japanese academic society dealing with joints should organize a system for education and training in surgical skills and techniques

Each surgeon specializing in a domain of orthopedics must learn many operative methods. If the effects of the various methods are the same, the surgeon should select the safest, most reliable operation with the least degree of surgical invasiveness. Any surgeon who employs the same operative method to treat all diseases and pathological situations must surely have poor learning skills. For instance, instead of using TOA to treat every subluxation of the hip joint with accompanying acetabular dysplasia, the surgeon should have a wide range of choices from which safer, more reliable operative methods can be selected, for example using a transtrochanteric curved varus osteotomy alone or co-use of a transtrochanteric curved varus osteotomy with some form of acetabuloplasty, such as the Spitzy method for a mild case.

It is also important to respect an original operative method and make an effort to learn it accurately. For instance, I find it unbelievable that some hip surgeons have used techniques unfaithful to the original method I designed for transtrochanteric rotational osteotomy and, furthermore, that even though bone scintigraphy showed silence in the rotated femoral head 5–6 weeks after surgery in 80% of cases they published papers criticizing the usefulness of this operative method. Moreover, many non-unions as a complication of this osteotomy has been reported by some hip surgeons outside Japan using cannulated screws or AO screws for subcapital fractures instead of using Yuge's venable screws for internal fixation. When a surgeon tries a new operative method and the result is poor, it is necessary to consider whether the technique used was faithful to the one originally described.

In accordance with medical ethics, a surgeon who intends to use a new operative method should at least make an effort to see and learn the operation as it is performed by the person who devised it. It is well to remember that such surgery is being performed on humans, not animal models. New operative methods per se are not to be discouraged, but the skills of the surgeons attempting them are occasionally not yet developed.

Surgeons who have devised new surgical methods should be prepared to accommodate anyone who wishes to observe his or her operation for study purposes. Furthermore, academic societies should have a system for authorizing and making official announcements about facilities with experience in a sufficient number of cases and that have obtained stable results for each new technique. After such a system has been established, each academic society has an important respon-

sibility for the future establishment of reliable medicine by providing convenient opportunities for young surgeons to try particular techniques and train in appropriate facilities, to introduce facilities that accept such young surgeons, and to make an effort to ensure that the techniques are taught and performed correctly and faithfully.

Awareness of the limits of artificial joints using artificial materials

Total hip replacement (THR) is an excellent operation so long as it is strictly applied to patients in the appropriate age range, except in some special cases such as rheumatoid arthritis for which we are obliged to ignore age constraints. However, because such replacements are done with artificial materials, many unsolved problems such as abrasion remain, and the materials naturally have limited applicability and a limited life span. In other words, we should remember that an artificial hip joint is not at all superior to viable tissues and organs.

The basis of medicine is not replacement by artificial materials but, rather, restoration of function by biological tissues in ways that encourage natural regeneration and remodeling, so organs can be reconstructed or their function compensated by other tissues and organs. Functional reconstruction using artificial internal organs, other organs, or tissues should be used only as the last option. When artificial materials are used in the human body, they should at least be applied with the expectation of future regeneration by biological tissues. For instance, the purpose of using artificial blood vessels and artificial bone is to provide a footing for regeneration by biological tissues, not permanently substitute an artificial material for them. We should remember that artificial ligaments, once popular for reconstructing cruciate ligaments in the knee, have ruptured, snapping like shoelaces, and have also caused reactive bone resorption, interfering with later reconstruction by biological tissues and ending with tragic results.

The organs and tissues encompassed by the field of orthopedics have extremely strong regenerative capacity, and therefore we should be cautious about making hasty substitutions using artificial materials. The primary duty of orthopedists is to preserve the living joints of patients whenever possible.

Danger of following the American policy of hip joint replacement surgery

For the past 10 years or more, presentations by American hip surgeons at the sessions of the International Hip Society have centered exclusively on THR. If asked why they do only THR even though there is an excellent osteotomy technique that can preserve patients' own hip joints, they reply that although osteotomy is an excellent procedure, and even if they want to perform it, it is no longer a socially acceptable option. The health insurance system in the United States differs from that in Japan, where everyone has insurance. In the United States, where private medical insurance companies provide medical services to make a profit, the choice of medical services is out of the hands of the physician and in the control of these companies. Under this system, it is easy to bring medical lawsuits, and so physicians have closed their eyes to the unfortunate outcomes that patients suffer 10–15 years after THR. They have been performing THR even for patients as young as 20 years of age. Although this approach eliminates pain within a relatively short period of time, it has tragic consequences later.

The fourth patient I treated by transtrochanteric rotational osteotomy 34 years ago when he was 24 years old and with osteonecrosis of the femoral head in stage 3A, is now 58 years old and still has completely normal hip joint function. X-ray films and MRI have shown that the necrotic lesions are completely healed, and the patient is enjoying a full life with his own hip joints. If this patient had undergone THR when he was 24, who can tell how much revision surgery he would have needed up to now?

To avoid going down the same misguided path of medical treatment as is traveled in the United States, Japanese orthopedists must carefully watch trends in our society, including changes in the medical system and the increase in medical lawsuits. Instead of tacitly permitting these changes and remaining spectators, for the sake of the people in Japan we must start to take action to correct the situation and prevent our field of medicine from advancing in the wrong direction.